DSP-FULBRECHT
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User Manual

Preliminary

Multichannel DTMF Receiver

for Analog Devices ADSP 218x

- Bellcore GR-506-CORE
- Dial Tone Supression
- A-Law, u-Law or Linear Inputs

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1. Overview

This program is a multichannel DTMF receiver for the Analog Devices DSP ADSP 218x family.
The program is written in assembler for optimizing MIPS and code memory.
In the interrupt routine only the new samples are stored into the buffers and searching for full of buffers, the DTMF Receiver Program is running in the main loop. In this way no time for peak MIPS will be needed in the interrupt routine.
The serial port can using data and voice at the same time. The A-Law or u-Law companding is running separately.
All cursive printed names are used in the assembler written programs.

2. Inputs

Each channel has an 80 word input buffer for 80 new samples. If 80 new samples are written into the input buffer, a call of this channel will search for DTMF signals. The input samples are A-Law, u_Law or Linear values. There are two buffers for inputs of each channel, one is used from the DTMF program, the other is used for filling a new 80 sample buffer. A pointer is set from the user to the new samples before the *dtmf_rec* program is called. A flag in *status* is set if a new buffer is full.

3. Outputs

Detected DTMF digits are written into a circular addressed output buffer. One pointer is used from the DSP for write into the buffer, an other pointer is used from the user for reading the buffer. The word in the buffer shows the DTMF digit and the channel number.

In the buffer *dtmf_dig* the DSP writes the channel number and the digit if a DTMF signal was detected. The buffer *dtmf_dig* is 32 word circular addressed. The DSP used the pointer *dtmf_in*, the user the pointer *dtmf_out*. If both pointers are equal, the buffer is empty. If a DTMF signal is written from the DSP in the buffer, the *dtmf_in* pointer is +1 updated (circular).

A word in *dtmf_dig* has the following value:

15…8	7	6	5	4	3	2	1	0
Channel	not used	not used	not used	not used	digit	digit	digit	digit

Key	digit(hex)
'1'	1
'2'	2
'3'	3
'4'	4
'5'	5
'6'	6
'7'	7
'8'	8
'9'	9
'0'	0
'*'	E
'#'	F
'A'	A
'B'	B
'C'	C
'D'	D
'E'	E

channel: The number of the channel

Example: 0x0703 Channel No. 7 had received a digit '3'
Example: 0x0000 Channel No. 0 had received a digit '0'
Example: 0x030E Channel No. 3 had received a digit '*'

4. Configuration

Each channels has a *status* word for configuration of the input values and buffer full/empty. The user must set one bit for A-Law, u_Law or Linear inputs and set bit 0 if the input buffer of this channel is full. After calling the DTMF-Program with the specified channel number, bit 0 is reset to 0 from the DTMF program. Normally the user fills the buffer in his interrupt routine and a call of the DTMF-Program is in the main loop.

Statusregister:

15…7	6	5	4	3	2	1	0
not used	not used	not used	not used	not used	A-Law	u-Law	new block

Bit 0: Set if 80 new samples in the buffer
Bit 1: Set if u-Law is used
Bit 2: Set if A-Law is used, if Bit 1 and Bit 2 = 0 then Linear Inputs

Input Range:

If A-Law is used, the *scale* factor for setting the inputrange is set to 0x0800, if u-Law is used, the scale factor is set to 0x0800, if Linear Inputs is used, the input range is corresponding to the length and range of the used A/D converter and the input range.

Input range	Resulotion	scale
A-Law	-	0x0800
u-Law	-	0x0800
+1 V … -1 V	14 Bit + Sign	0xyyyy (later)
+1 V … -1 V	13 Bit + Sign	0xyyyy (later)
+1 V … -1 V	12 Bit + Sign	0xzzzz (later)

Table1, Input Range

5. Using Multichannel

Each channel must called if 80 new input samples of all channels are written into the buffer. The user set the bit new_block in *status[channel]* to 1, writes the channel number to ax0 and call then the DTMF receiver program *dtmf_rec*. The program *dtmf_rec* clears the new_block bit in *status[channel]*.

6. Memory

Program Memory and Coefficients: 780 Words

Data Memory: 534 Words + 196 * channel Words

7. MIPS

Channels * 0.88 (one call *dtmf_rec*)

8. Delivery

dtmf_rec.asm	Assembler program (Analog Devices ADSP 218x)
dtmf_rec.inc	Including file, all data declarations
dtmf_rec.obj	Object code

9. Example

4 channels, A-Law. This program can be downloaded (DTMF_TST.ASM)

```
{************************************************************************}
{* Test the Analog Devices Multichannel DTMF Receiver with the Simulator   *}
{* Copyright Ingenieurbuero Gerd Fulbrecht, Mattersburger Weg 2, Berlin    *}
{*                                                                         *}
{* This program loads A-Law samples from IO ports to the buffer of the     *}
{* DTMF Receiver Program and searched for detected digits.                 *}
{* 4 Channel Example                          Rev. 1.0  October 22.2001  *}
{************************************************************************}

.module/RAM/ABS=0  DTMF_TST;

{ The .external data are defind in dtmf.inc }

.external    dtmf_chan;            { Number of used channels                }
.external    sample;               { Buffer for input samples               }
.external    input_ptr;            { Buffer used in dtmf_rec.asm            }
.external    status;               { Status of the channels                 }
.external    dtmf_dig;             { Buffer of detected digits (output)     }
.external    dtmf_in;              { Pointer dtmf_dig used in dtmf_rec program  }
.external    dtmf_out;             { Pointer dtmf_dig used from the user    }



dtmf_init:   l0 = 0;
             l1 = 0;
             l2 = 0;
             l3 = 0;
             l4 = 0;
             l5 = 0;
             l6 = 0;
             l7 = 0;


test_loop:


      {  80 new input samples to sample[0..79] for channel 0 }

             cntr = 80;
             i0=^sample;
             dm(input_ptr)=i0;     { set the input pointer channel #0 }
             l0=0;
             m0=1;
             do   load_loop_0 until ce;
                ax0=io(0);
load_loop_0:    dm(i0,m0)=ax0;


             ax0=0x0005;
             dm(status)=ax0;       { status #0: A-Law, Buffer full }
```

```
      {  80 new values to sample[160..] for channel 1 }

              cntr = 80;
              i0=^sample+160;
              l0=0;
              dm(input_ptr+1)=i0;  { set the input pointer channel #1 }
              m0=1;
              do   load_loop_1 until ce;
                 ax0=io(1);
load_loop_1:     dm(i0,m0)=ax0;

              ax0=0x0005;
              dm(status+1)=ax0;     { status #1: A-Law, Buffer full }


      {  80 new values to sample[320..] for channel 2 }

              cntr = 80;
              i0=^sample+320;
              dm(input_ptr+2)=i0;  { set the input pointer channel #2 }
              l0=0;
              m0=1;
              do   load_loop_2 until ce;
                 ax0=io(2);
load_loop_2:     dm(i0,m0)=ax0;

              ax0=0x0005;
              dm(status+2)=ax0;     { status #2: A-Law, Buffer full }


      {  80 new values to sample[480..] for channel 3 }

              cntr = 80;
              i0=^sample+480;
              dm(input_ptr+3)=i0;  { set the input pointer channel #3 }
              l0=0;
              m0=1;
              do   load_loop_3 until ce;
                 ax0=io(3);
load_loop_3:     dm(i0,m0)=ax0;

              ax0=0x0005;
              dm(status+3)=ax0;     { status #3: A-Law, Buffer full }



              {* call dtmf_rec for each channel *}

              ax0 = 0;                { channel #0 }
              call  dtmf_rec;

              ax0 = 1;                { channel #1 }
              call  dtmf_rec;

              ax0 = 2;                { channel #2 }
              call  dtmf_rec;

              ax0 = 3;                { channel #3 }
              call  dtmf_rec;
```

```
      {* test if any DTMF digit detected and store the digits in IO *}

host_loop:
              ax0=dm(dtmf_in);            { Input Pointer  dtmf_rec.asm  }
              ay0=dm(dtmf_out);           { Output Pointer     user       }

              ar = ax0-ay0;
              if eq jump test_loop;       { buffer empty if the pointers are equal }

              i0=ay0;
              l0=%dtmf_dig;               { circular buffer }
              m0=1;
              ax0=dm(i0,m0);
              sr0=ax0;
              sr = ashift sr0 by -8 (lo); { sr0 now the channel number }

              ar = pass sr0;
              if eq jump store_chan_0;
              ax1 = sr0;
              ar = ax1 - 1;
              if eq jump store_chan_1;
              ar = ax1 - 2;
              if eq jump store_chan_2;

             { store channel #3 digit }

              i0=dm(dtmf_out);      { pointer user }
              ax0=dm(i0,m0);
              io(3) = ax0;          { write the digit to IO port 3 }
              dm(dtmf_out)=i0;

              jump   host_loop;

            { store channel #0 digit }

store_chan_0:
             i0=dm(dtmf_out);       { pointer user }
             ax0=dm(i0,m0);
             io(0) = ax0;           { write the digit to IO port 0 }
             dm(dtmf_out)=i0;

             jump  host_loop;

            { store channel #1 digit }

store_chan_1:
             i0=dm(dtmf_out);       { pointer user }
             ax0=dm(i0,m0);
             io(1) = ax0;           { write the digit to IO port 1 }
             dm(dtmf_out)=i0;

             jump  host_loop;

            { store channel #2 digit }

store_chan_2:
             i0=dm(dtmf_out);       { pointer user }
             ax0=dm(i0,m0);
             io(2) = ax0;           { write the digit to IO port 2 }
             dm(dtmf_out)=i0;

             jump  host_loop;


             .endmod;
```

10. Performance
10.1 Detect Test

The following tests are repeating the digits 1,2,3,4,5,6,7,8,9,0,*,#,A,B,C,D 5 times. The pause time of 41ms is used for changing the start time of a new pulse detection. The DTMF receiver using blocks of 80 samples = 10ms. If pause time = 40 ms, each new DTMF pulse starts with the beginning of a new 80 sample block. Each test must detect 80 digits. All test sequenciies are A-Law.

Both levels equal

Test N0.	low freq.	low level	high freq.	high level	pulse time	pause time	dialtone		Result digits
1	-1.5%	0 dBm0	-1.5%	0 dBm0	40 ms	41 ms	-	-	80 no fail
2	+1.5%	0 dBm0	+1.5%	0 dBm0	40 ms	41 ms	-	-	80 no fail
3	+1.5%	0 dBm0	-1.5%	0 dBm0	40 ms	41 ms	-	-	80 no fail
4	-1.5%	0 dBm0	+1.5%	0 dBm0	40 ms	41 ms	-	-	80 no fail
5	-1.5%	-15 dBm0	-1.5%	-15 dBm0	40 ms	41 ms	-	-	80 no fail
6	+1.5%	-15 dBm0	+1.5%	-15 dBm0	40 ms	41 ms	-	-	80 no fail
7	+1.5%	-15 dBm0	-1.5%	-15 dBm0	40 ms	41 ms	-	-	80 no fail
8	-1.5%	-15 dBm0	+1.5%	-15 dBm0	40 ms	41 ms	-	-	80 no fail
9	-1.5%	-25 dBm0	-1.5%	-25 dBm0	40 ms	41 ms	-	-	80 no fail
10	+1.5%	-25 dBm0	+1.5%	-25 dBm0	40 ms	41 ms	-	-	80 no fail
11	+1.5%	-25 dBm0	-1.5%	-25 dBm0	40 ms	41 ms	-	-	80 no fail
12	-1.5%	-25 dBm0	+1.5%	-25 dBm0	40 ms	41 ms	-	-	80 no fail

Twist, higher level –8 dBm

Test N0.	low freq.	low level	high freq.	high level	pulse time	pause time	dialtone		Result digits
13	-1.5%	-1 dBm0	-1.5%	-9 dBm0	40 ms	41 ms	-	-	80 no fail
14	+1.5%	-1 dBm0	+1.5%	-9 dBm0	40 ms	41 ms	-	-	80 no fail
15	+1.5%	-1 dBm0	-1.5%	-9 dBm0	40 ms	41 ms	-	-	80 no fail
16	-1.5%	-1 dBm0	+1.5%	-9 dBm0	40 ms	41 ms	-	-	80 no fail
17	-1.5%	-12 dBm0	-1.5%	-20 dBm0	40 ms	41 ms	-	-	80 no fail
18	+1.5%	-12 dBm0	+1.5%	-20 dBm0	40 ms	41 ms	-	-	80 no fail
19	+1.5%	-12 dBm0	-1.5%	-20 dBm0	40 ms	41 ms	-	-	80 no fail
20	-1.5%	-12 dBm0	+1.5%	-20 dBm0	40 ms	41 ms	-	-	80 no fail
21	-1.5%	-17 dBm0	-1.5%	-25 dBm0	40 ms	41 ms	-	-	80 no fail
22	+1.5%	-17 dBm0	+1.5%	-25 dBm0	40 ms	41 ms	-	-	80 no fail
23	+1.5%	-17 dBm0	-1.5%	-25 dBm0	40 ms	41 ms	-	-	80 no fail
24	-1.5%	-17 dBm0	+1.5%	-25 dBm0	40 ms	41 ms	-	-	80 no fail

Twist, higher level + 4 dBm

Test N0.	low freq.	low level	high freq.	high level	pulse time	pause time	dialtone		Result digits
25	-1.5%	-4 dBm0	-1.5%	0 dBm0	40 ms	41 ms	-	-	80 no fail
26	+1.5%	-4 dBm0	+1.5%	0 dBm0	40 ms	41 ms	-	-	80 no fail
27	-1.5%	-4 dBm0	-1.5%	0 dBm0	40 ms	41 ms	-	-	80 no fail
28	+1.5%	-4 dBm0	+1.5%	0 dBm0	40 ms	41 ms	-	-	80 no fail
29	-1.5%	-15 dBm0	-1.5%	-11 dBm0	40 ms	41 ms	-	-	80 no fail
30	+1.5%	-15 dBm0	+1.5%	-11 dBm0	40 ms	41 ms	-	-	80 no fail
31	-1.5%	-15 dBm0	-1.5%	-11 dBm0	40 ms	41 ms	-	-	80 no fail
32	+1.5%	-15 dBm0	+1.5%	-11 dBm0	40 ms	41 ms	-	-	80 no fail
33	-1.5%	-25 dBm0	-1.5%	-21 dBm0	40 ms	41 ms	-	-	80 no fail
34	+1.5%	-25 dBm0	+1.5%	-21 dBm0	40 ms	41 ms	-	-	80 no fail
35	-1.5%	-25 dBm0	-1.5%	-21 dBm0	40 ms	41 ms	-	-	80 no fail
36	+1.5%	-25 dBm0	+1.5%	-21 dBm0	40 ms	41 ms	-	-	80 no fail

Test 100 … 136 like test 1…36 but additional dial tone present, in pulse and pause time.

both levels equal

Test N0.	low freq.	low level	high freq.	high level	pulse time	pause time	dial tone 350 Hz dBm0	dial tone 440 Hz dBm0	Result digits
101	-1.5%	0 dBm0	-1.5%	0 dBm0	40 ms	41 ms	-18	-18	80 no fail
102	+1.5%	0 dBm0	+1.5%	0 dBm0	40 ms	41 ms	-18	-18	80 no fail
103	+1.5%	0 dBm0	-1.5%	0 dBm0	40 ms	41 ms	-18	-18	80 no fail
104	-1.5%	0 dBm0	+1.5%	0 dBm0	40 ms	41 ms	-18	-18	80 no fail
105	-1.5%	-15 dBm0	-1.5%	-15 dBm0	40 ms	41 ms	-18	-18	80 no fail
106	+1.5%	-15 dBm0	+1.5%	-15 dBm0	40 ms	41 ms	-18	-18	80 no fail
107	+1.5%	-15 dBm0	-1.5%	-15 dBm0	40 ms	41 ms	-18	-18	80 no fail
108	-1.5%	-15 dBm0	+1.5%	-15 dBm0	40 ms	41 ms	-18	-18	80 no fail
109	-1.5%	-25 dBm0	-1.5%	-25 dBm0	40 ms	41 ms	-18	-18	80 no fail
110	+1.5%	-25 dBm0	+1.5%	-25 dBm0	40 ms	41 ms	-18	-18	80 no fail
111	+1.5%	-25 dBm0	-1.5%	-25 dBm0	40 ms	41 ms	-18	-18	80 no fail
112	-1.5%	-25 dBm0	+1.5%	-25 dBm0	40 ms	41 ms	-18	-18	80 no fail

Twist, higher level –8 dBm

Test N0.	low freq.	low level	high freq.	high level	pulse time	pause time	dial tone 350 Hz dBm0	dial tone 440 Hz dBm0	Result digits
113	-1.5%	0 dBm0	-1.5%	-8 dBm0	40 ms	41 ms	-18	-18	80 no fail
114	+1.5%	0 dBm0	+1.5%	-8 dBm0	40 ms	41 ms	-18	-18	80 no fail
115	+1.5%	0 dBm0	-1.5%	-8 dBm0	40 ms	41 ms	-18	-18	80 no fail
116	-1.5%	0 dBm0	+1.5%	-8 dBm0	40 ms	41 ms	-18	-18	80 no fail
117	-1.5%	-12 dBm0	-1.5%	-20 dBm0	40 ms	41 ms	-18	-18	80 no fail
118	+1.5%	-12 dBm0	+1.5%	-20 dBm0	40 ms	41 ms	-18	-18	80 no fail
119	+1.5%	-12 dBm0	-1.5%	-20 dBm0	40 ms	41 ms	-18	-18	80 no fail
120	-1.5%	-12 dBm0	+1.5%	-20 dBm0	40 ms	41 ms	-18	-18	80 no fail
121	-1.5%	-17 dBm0	-1.5%	-25 dBm0	40 ms	41 ms	-18	-18	80 no fail
122	+1.5%	-17 dBm0	+1.5%	-25 dBm0	40 ms	41 ms	-18	-18	80 no fail
123	+1.5%	-17 dBm0	-1.5%	-25 dBm0	40 ms	41 ms	-18	-18	80 no fail
124	-1.5%	-17 dBm0	+1.5%	-25 dBm0	40 ms	41 ms	-18	-18	80 no fail

Twist, higher level + 4 dBm

Test N0.	low freq.	low level	high freq.	high level	pulse time	pause time	dial tone 350 Hz dBm0	dial tone 440 Hz dBm0	Result digits
125	-1.5%	-4 dBm0	-1.5%	0 dBm0	40 ms	41 ms	-18	-18	80 no fail
126	+1.5%	-4 dBm0	+1.5%	0 dBm0	40 ms	41 ms	-18	-18	80 no fail
127	-1.5%	-4 dBm0	-1.5%	0 dBm0	40 ms	41 ms	-18	-18	80 no fail
128	+1.5%	-4 dBm0	+1.5%	0 dBm0	40 ms	41 ms	-18	-18	80 no fail
129	-1.5%	-15 dBm0	-1.5%	-11 dBm0	40 ms	41 ms	-18	-18	80 no fail
130	+1.5%	-15 dBm0	+1.5%	-11 dBm0	40 ms	41 ms	-18	-18	80 no fail
131	-1.5%	-15 dBm0	-1.5%	-11 dBm0	40 ms	41 ms	-18	-18	80 no fail
132	+1.5%	-15 dBm0	+1.5%	-11 dBm0	40 ms	41 ms	-18	-18	80 no fail
133	-1.5%	-25 dBm0	-1.5%	-21 dBm0	40 ms	41 ms	-18	-18	80 no fail
134	+1.5%	-25 dBm0	+1.5%	-21 dBm0	40 ms	41 ms	-18	-18	80 no fail
135	-1.5%	-25 dBm0	-1.5%	-21 dBm0	40 ms	41 ms	-18	-18	80 no fail
136	+1.5%	-25 dBm0	+1.5%	-21 dBm0	40 ms	41 ms	-18	-18	80 no fail

10.2 SNR

GR-506-Core R15-18, but flat white noise: Pass, all 10000 digits detect

10.3 Not Detect Test

Like Test 1…36, but +3.5% and –3.5% nominal frequencies, Pulslength 60ms

Both levels equal

Test N0.	low freq.	low level	high freq.	high level	pulse time	pause time	dialtone		Result digits
501	-3.5%	0 dBm0	-3.5%	0 dBm0	60 ms	61 ms	-	-	0 no fail
502	+3.5%	0 dBm0	+3.5%	0 dBm0	60 ms	61 ms	-	-	0 no fail
503	+3.5%	0 dBm0	-3.5%	0 dBm0	60 ms	61 ms	-	-	0 no fail
504	-3.5%	0 dBm0	+3.5%	0 dBm0	60 ms	61 ms	-	-	0 no fail
505	-3.5%	-15 dBm0	-3.5%	-15 dBm0	60 ms	61 ms	-	-	0 no fail
506	+3.5%	-15 dBm0	+3.5%	-15 dBm0	60 ms	61 ms	-	-	0 no fail
507	+3.5%	-15 dBm0	-3.5%	-15 dBm0	60 ms	61 ms	-	-	0 no fail
508	-3.5%	-15 dBm0	+3.5%	-15 dBm0	60 ms	61 ms	-	-	0 no fail
509	-3.5%	-25 dBm0	-3.5%	-25 dBm0	60 ms	61 ms	-	-	0 no fail
510	+3.5%	-25 dBm0	+3.5%	-25 dBm0	60 ms	61 ms	-	-	0 no fail
511	+3.5%	-25 dBm0	-3.5%	-25 dBm0	60 ms	61 ms	-	-	0 no fail
512	-3.5%	-25 dBm0	+3.5%	-25 dBm0	60 ms	61 ms	-	-	0 no fail

Lower frequencies +/- 3.5%, Higher frequencies nominal

Test N0.	low freq.	low level	high freq.	high level	pulse time	pause time	dialtone		Result digits
513	-3.5%	0 dBm0	nom.	0 dBm0	60 ms	61 ms	-	-	0 no fail
514	+3.5%	0 dBm0	nom.	0 dBm0	60 ms	61 ms	-	-	0 no fail
515	-3.5%	-8 dBm0	nom.	-8 dBm0	60 ms	61 ms	-	-	0 no fail
516	+3.5%	-8 dBm0	nom.	-8 dBm0	60 ms	61 ms	-	-	0 no fail
517	-3.5%	-12 dBm0	nom.	-12 dBm0	60 ms	61 ms	-	-	0 no fail
518	+3.5%	-12 dBm0	nom.	-12 dBm0	60 ms	61 ms	-	-	0 no fail
519	-3.5%	-18 dBm0	nom.	-18 dBm0	60 ms	61 ms	-	-	0 no fail
520	+3.5%	-18 dBm0	nom.	-18 dBm0	60 ms	61 ms	-	-	0 no fail
521	-3.5%	-22 dBm0	nom.	-22 dBm0	60 ms	61 ms	-	-	0 no fail
522	+3.5%	-22 dBm0	nom.	-22 dBm0	60 ms	61 ms	-	-	0 no fail
523	-3.5%	-25 dBm0	nom.	-25 dBm0	60 ms	61 ms	-	-	0 no fail
524	+3.5%	-25 dBm0	nom.	-25 dBm0	60 ms	61 ms	-	-	0 no fail

Lower Frequencies nominal, Higher frequencies +/- 3.5%

Test N0.	low freq.	low level	high freq.	high level	pulse time	pause time	dialtone		Result digits
525	nom.	0 dBm0	-3.5%	0 dBm0	60 ms	61 ms	-	-	0 no fail
526	nom.	0 dBm0	+3.5%	0 dBm0	60 ms	61 ms	-	-	0 no fail
527	nom.	-8 dBm0	-3.5%	-8 dBm0	60 ms	61 ms	-	-	0 no fail
528	nom.	-8 dBm0	+3.5%	-8 dBm0	60 ms	61 ms	-	-	0 no fail
529	nom.	-12 dBm0	-3.5%	-12 dBm0	60 ms	61 ms	-	-	0 no fail
530	nom.	-12 dBm0	+3.5%	-12 dBm0	60 ms	61 ms	-	-	0 no fail
531	nom.	-18 dBm0	-3.5%	-18 dBm0	60 ms	61 ms	-	-	0 no fail
532	nom.	-18 dBm0	+3.5%	-18 dBm0	60 ms	61 ms	-	-	0 no fail
533	nom.	-22 dBm0	-3.5%	-22 dBm0	60 ms	61 ms	-	-	0 no fail
534	nom.	-22 dBm0	+3.5%	-22 dBm0	60 ms	61 ms	-	-	0 no fail
535	nom.	-25 dBm0	-3.5%	-25 dBm0	60 ms	61 ms	-	-	0 no fail
536	nom.	-25 dBm0	+3.5%	-25 dBm0	60 ms	61 ms	-	-	0 no fail

Pulse 23 ms, Pause 40 ms, digits 1,2,3,4,5,6,7,8,9,0,*,#,A,B,C,D repeated 5 times

Test N0.	low freq.	low level	high freq.	high level	pulse time	pause time	dial tone 350 Hz dBm0	dial tone 440 Hz dBm0	Result digits
601	nom.	0 dBm0	nom.	0 dBm0	23 ms	40 ms	-	-	0 no fail
602	nom.	-5 dBm0	nom.	-5 dBm0	23 ms	40 ms	-	-	0 no fail
603	nom.	-7 dBm0	nom.	-7 dBm0	23 ms	40 ms	-	-	0 no fail
604	nom.	-9 dBm0	nom.	-9 dBm0	23 ms	40 ms	-	-	0 no fail
605	nom.	-11 dBm0	nom.	-11 dBm0	23 ms	40 ms	-	-	0 no fail
606	nom.	-13 dBm0	nom.	-13 dBm0	23 ms	40 ms	-	-	0 no fail
607	nom.	-15 dBm0	nom.	-15 dBm0	23 ms	40 ms	-	-	0 no fail
608	nom.	-17 dBm0	nom.	-17 dBm0	23 ms	40 ms	-	-	0 no fail
609	nom.	-19 dBm0	nom.	-19 dBm0	23 ms	40 ms	-	-	0 no fail
610	nom.	-21 dBm0	nom.	-21 dBm0	23 ms	40 ms	-	-	0 no fail
611	nom.	-23 dBm0	nom.	-23 dBm0	23 ms	40 ms	-	-	0 no fail
612	nom.	-25 dBm0	nom.	-25 dBm0	23 ms	40 ms	-	-	0 no fail

10.4 Level –55 dBm0

700	nom.	-55 dBm0	nom.	-55 dBm0	60 ms	41 ms	-	-	0 no fail

10.5 Speech Immunity

Mitel talk-off tape CM-7291: Pass, xx detection (under test)